MODELING A BACKDRAFT INCIDENT: THE 62 WATTS ST. (NY) FIRE

Richard W. Bukowski, P.E.
NIST, Building and Fire Research Laboratory
Gaithersburg, MD, 20899-0001 USA

ABSTRACT

On March 28, 1994, the New York City Fire Department (FDNY) responded to a report of smoke and sparks issuing from a chimney at a three story apartment building in Manhattan. The officer in charge ordered three- person hose teams to make entry into the first- and second-floor apartments while the truck company ventilated the stairway from the roof. When the door to the first-floor apartment was forced open, a large flame issued from the apartment and up the stairway, engulfing the three firefighters at the second floor landing. The flame persisted for at least 6½ minutes, resulting in their deaths. The FDNY requested the assistance of the National Institute of Standards and Technology (NIST) to model the incident in the hope of understanding the factors which produced a backdraft condition of such a duration. The CFAST model was able to reproduce the observed conditions and supported a theory of the accumulation of significant quantities of unburned fuel from a vitiated fire in an apartment which had been insulated and sealed for energy efficiency.

THE BUILDING

The fire occurred in a three story, multiple brick dwelling of ordinary construction approximately 6.1 m (20 ft) wide by 14 m (46 ft) deep, and 3½ stories tall. The building contained four apartments, one on each story, with the basement apartment half below grade. While the basement apartment had its own entrance, access to the others was by an enclosed stairway running up the side of the building. The building was attached to an identical building (64 Watts St.) that was not involved.

The buildings were built in the late 1800's and had undergone many alterations over the years. Recent renovations included replacement of the plaster/lathe with drywall on wood studs, lowering the ceilings to 2.5 m (8.25 ft), new windows and doors, heavy thermal insulation, sealing and calking to minimize air infiltration (the building was described as very tight.). Built before central heat, the apartments had numerous fireplaces, most of which had been sealed. The apartment of fire origin had 2 fireplaces, but only the one in the living room was operable. All apartments had thick plank wood floors.

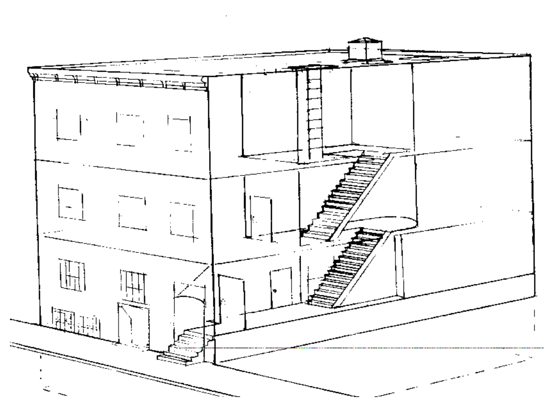


Figure 1 - 62 Watts St.

The apartments had similar floorplans; the differences resulting from the stairway. A floorplan of the first floor apartment is presented in figure 2. There was a living room in the front, kitchen and bathroom in the center, and a bedroom in the rear. Not found in the other apartments, the first floor apartment had an office within the bedroom which was not significant in the fire. The roof had a scuttle for access and a wired glass skylight located over the stairway.

THE INCIDENT

On March 28, 1994 at 7:36pm, the New York City Fire Department received a telephone report of heavy smoke and sparks coming from a chimney at 62 Watts St., Manhattan. The initial response was 3 engines, 2 ladders, and a battalion chief. On arrival they saw the smoke from the chimney but no other signs of fire. The engine companies were assigned to ventilate the roof above the stairs by opening the scuttle and skylight, and two three-person hose teams advanced lines through the main entrance to the first- and second-floor apartment doors.

The first-floor hose team forced the apartment door and reported:

- a momentary rush of air into the apartment, followed by
- a warm (but not hot) exhaust, followed by
- a large flame issuing from the upper part of the door and extending up the stairway.

The first-floor team was able to duck down under the flame and retreat down the stairs, but the three men at the second-floor level were engulfed by the flame which now filled the stairway. An amateur video was being taken from across the street and became an important source of information when later reviewed by the fire department. This showed the flame filling the stairway and venting out the open scuttle and skylight, extending well above the roof of the building. Further, the video showed that the flame persisted at least 6½ minutes (the tape had several pauses of unknown duration, but there was 6½ minutes of tape showing the flame).

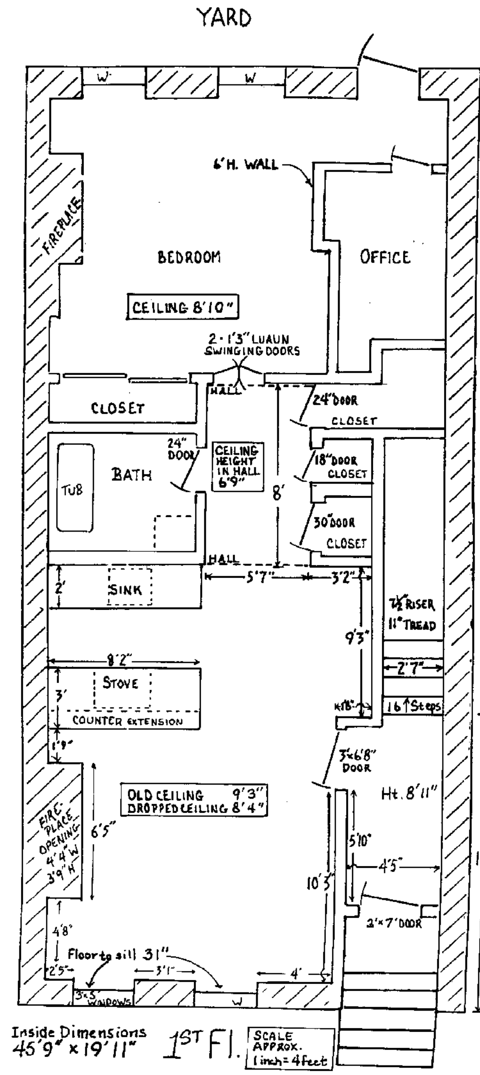
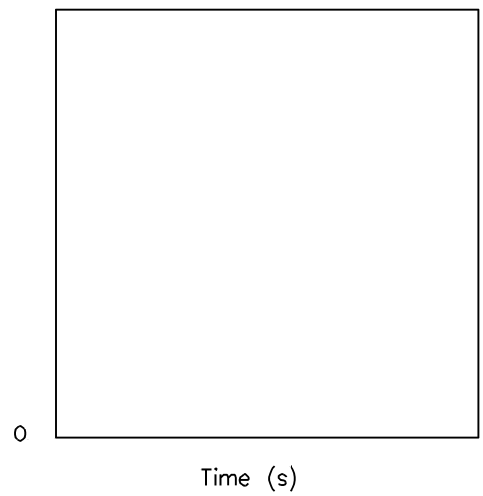


Figure 2 - First floor apartment

Damage to the apartment of origin was limited to the living room, kitchen and hall -- closed doors prevented fire spread to the bedroom, bath, office, and closets. There was no fire extension to the other apartments and no structural damage. The wired glass in the skylight was melted in long "icicles" and the wooden stairs were mostly consumed. The description provided by the surviving hose team was of a classic backdraft; but these usually persist only seconds before exhausting their fuel supply. Where did the fuel come from to feed this flame for so long?

CAUSE AND ORIGIN

The subsequent investigation revealed that the first-floor occupant went out at 6:25pm, leaving a plastic trash bag atop the (gas) kitchen range which he was sure was turned off. It is reasonable that the pilot light ignited the bag, which then involved several bottles of high alcohol content liquor on the counter, and spread the fire to the wood floor and other contents. The occupant confirmed that all doors and windows were closed, so that the only source of combustion air was the fireplace flue in the living room from which the smoke and sparks were seen to emerge.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Time (s)

reported by the firefighters. This door flame grew within a few seconds to a peak burning rate of nearly 5 MW (fig. 6), raising the temperature in the stairway to over 1200 ºC (2200 ºF) (fig. 5) -- sufficient to melt the glass in the skylight, as observed. Most importantly, the quantity of unburned fuel accumulated in the apartment caused the door flame to persist for more than 7 minutes (fig. 6).

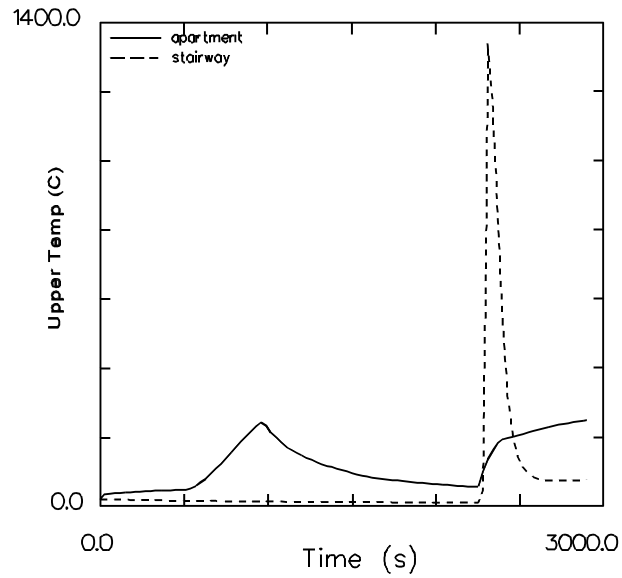

Figure 5 - Upper temperatures

DISCUSSION

The CFAST calculations showed that the theory of the development of this fire was technically sound. They supported the hypothesis that unburned fuel and CO accumulated in an apartment with an open fireplace flue but otherwise tightly sealed, resulting in a backdraft on opening of the apartment door. They showed that sufficient fuel could accumulate under these underventilated conditions to cause the door flame to persist for the extended period observed. Reported conditions such as smoke flowing out the fireplace chimney, flows observed in the doorway, melting of the glass skylight, and fire damage in the apartment and stairway, all were reproduced by the model.

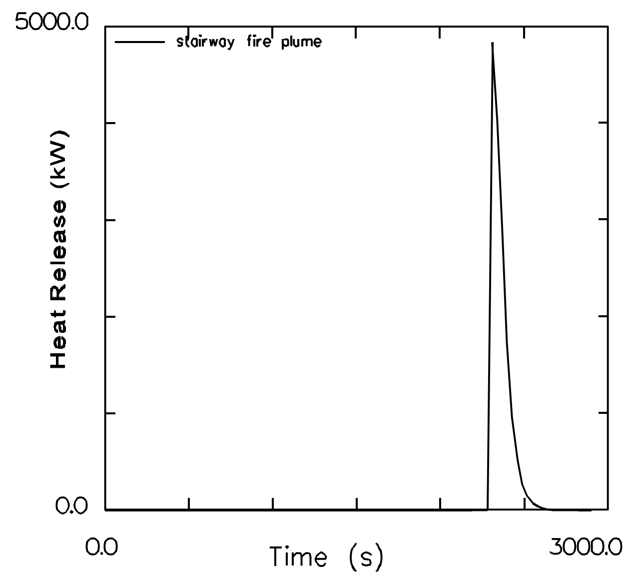

Figure 6 - HRR of door flame

Some assumptions were necessary in performing these calculations which may have an impact on the model's predictions. The results are sensitive to the volume of the apartment and to the size and locations of ventilation openings. All of these were accurately known by actual measurements taken by the fire department during their investigation. It was reported that the apartment was very tightly sealed, so the assumption of no additional leakage was justified. Ventilation provided by the fireplace flue was based on actual dimensions.

The combustion was predominately ventilation controlled, making the results insensitive to fuel loading and the specific burning characteristics of the fuel. The generation rate of unburned fuel should be affected by energy feedback from the environment and any flames present during the time of ventilation controlled combustion. The CFAST model does not contain such a self-consistant combustion model, so these effects were not included, and the quantity of unburned fuel could be overpredicted by an unknown amount. Such overprediction would tend to increase the duration of the door flame (but not its peak value). Since the duration of the flame matched that observed, either the effect is small or there were compensating errors in the estimate of the extent of fire involvement. The fire was in steady-state for a significant period prior to the time assumed for opening the door, so the predicted results are insensitive to that time. The backdraft condition occurred spontaneously in the model when the door was opened.

LESSONS LEARNED

In follow-up discussions with the New York City Fire Department, they concluded that, while the fire service has long recognized the dangers of backdraft, the unusually long duration of the flame under these conditions represents a hazard against which their protective equipment is ineffective. As buildings become better insulated and sealed for energy efficiency such hazards to firefighters may become increasingly common. Thus, new operational procedures need to be developed to reduce the likelihood of exposure to flames of this duration.

The fire department also reported that, as a result of the publicity surrounding this incident, a small number of similar incidents were reported to the fire department's safety division which had occurred before this one, but which had gone unreported because no one had been injured. This fact reinforces the need for improved operational procedures. The success of this exercise also pointed out the benefits of the use of modern, computer fire modeling in the reconstruction of fire incidents to understand critical factors for mitigating their impacts.

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